

## **Self-Repairing Fatigue Damage in Metallic Structures for Aerospace Vehicles Using Liquid-Assisted Shape Memory Alloy Self-Healing (SMASH) Technology**

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### **Abstract**

Development and optimization of metal-matrix composites (MMCs) with fatigue-crack self-repair capability was achieved through this Phase II Seedling project. During Phase I, Shape Memory Alloy Self-Healing (SMASH) technology, an aluminum-based matrix with Shape Memory Alloy (SMA) reinforcements that can self-repair existing fatigue cracks, was developed. Phase II has concentrated on refining fabrication techniques, evaluating heat treatments, optimizing the liquid-assisted healing treatment, and using finite element analysis (FEA) to model reinforcement architectures for full crack closure. Focus was placed on developing a composite system that can be a viable material for aeronautics applications where fatigue crack initiation and propagation is a significant safety and economic concern. The benefits of having self-repairing MMCs in aeronautical applications include increased reliability and damage tolerance, thus improved safety margins. FEA simulations using a three dimensional constitutive model of SMAs that describes evolution of elastic, transformation and plastic strains was adopted. The model was validated with visual image correlation (VIC) strain evolution data in various material systems. Modeling showed the optimal SMA reinforcement length, placement, orientation, and pre-straining conditions necessary to overcome the plasticity in the matrix and ensure full crack closure. These FEA conclusions helped to further study the design and optimization of the SMASH systems with various architectures that could not be performed experimentally. Results from healing optimization, oriented reinforcement, fatigue crack growth with VIC, and other empirical experiments on a binary matrix composite will be discussed. Additionally, newly designed precipitation strengthened ternary matrix alloys will be presented as candidates for self-repair.